WHAT IS CLAIMED IS:

1. A magnetoresistive effect element comprising:

a magnetoresistive effect film including a magnetization-pinned layer having a magnetic film whose direction of magnetization is pinned substantially in one direction, a magnetization free layer having a magnetic film whose direction of magnetization varies in response to an external magnetic field, a nonmagnetic metallic intermediate layer interposed between said magnetization-pinned layer and said magnetization free layer, and a resistance adjustment layer interposed between said magnetization-pinned layer and said magnetization free layer and made of a material containing a quantity of conductive carriers not more than $10^{22}/cm^3$; and

a pair of electrodes electrically coupled to said magnetoresistive effect film to supply a sense current substantially vertically of the film plane of said magnetoresistive effect film.

2. A magnetoresistive effect element according to claim 1, wherein said resistance adjustment layer is interposed at least in one of a location between said magnetization-pinned layer and said nonmagnetic metallic intermediate layer and a location between said magnetization free layer and said nonmagnetic metallic intermediate layer.

3. A magnetoresistive effect element according to claim 1, wherein said resistance adjustment layer is interposed in said

nonmagnetic metallic intermediate layer.

4. A magnetoresistive effect element according to claim 1, wherein said resistance adjustment layer is made of a semiconductor or a semimetal.

5. A magnetoresistive effect element according to claim 1, wherein said resistance adjustment layer contains as its major component one material selected from the group consisting of C, Si, Ge, AlN, GaN, InN, AlP, AlAs, AlSb, GaP, GaAs, GaSb, InP, InAs, InSb, ZnO, β-ZnS, ZnSe, ZnTe, CdS, CdTe, HgTe, α-SiC, β-SiC, PbS, PbSe, PbTe, SnTe, $CuInSe_2$, $FeSi_{2.43}$, β-$FeSi_2$, $MnSi_{1.72}$, $CrSi_2$, $(Cr_{1-x}Mn_x)Si_2$, Mg_2Si, $BaSi_2$, $ReSi_{1.75}$, $RuSi_3$, $OsSi_2$ and Ir_3Si_5.

6. A magnetoresistive effect element according to claim 1, wherein said resistance adjustment layer contains as its major component one material selected from the group consisting of graphite, As, Sb, Bi, HgTe, HgSe, CoSi, $(Co_{1-x}Fe_x)Si$, $(Co_{1-x}Ni_x)Si$, $(Co_{1-x}Mn_x)Si$, $(Co_{1-x}Cr_x)Si$ and FeS.

7. A magnetoresistive effect element according to claim 1, wherein a thickness of said resistance adjustment layer is equal to or less than 1 nm.

8. A magnetoresistive effect element according to claim 1, further comprising an insulating layer located adjacent to said

resistance adjustment layer and made of an oxide.

9. A magnetoresistive effect element according to claim 8, wherein said insulating layer is located nearer to a supply side of electrons forming said sense current with respect to said resistance adjustment layer.

10. A magnetoresistive effect element comprising:

a magnetoresistive effect film including a magnetization-pinned layer having a magnetic film whose direction of magnetization is pinned substantially in one direction, a magnetization free layer having a magnetic film whose direction of magnetization varies in response to an external magnetic field, and a nonmagnetic metallic intermediate layer interposed between said magnetization-pinned layer and said magnetization free layer;

a pair of electrodes electrically coupled to said magnetoresistive effect film to supply a sense current substantially vertically of the film plane of said magnetoresistive effect film,

wherein said nonmagnetic intermediate layer is a resistance adjustment layer made of a material containing conductive carriers not more than $10^{22}/cm^3$.

11. A magnetoresistive effect element according to claim 10, wherein said resistance adjustment layer is made of a semiconductor or a semimetal.

12. A magnetoresistive effect element according to claim 10, wherein said resistance adjustment layer contains as its major component one material selected from the group consisting of C, Si, Ge, AlN, GaN, InN, AlP, AlAs, AlSb, GaP, GaAs, GaSb, InP, InAs, InSb, ZnO, β-ZnS, ZnSe, ZnTe, CdS, CdTe, HgTe, α-SiC, β-SiC, PbS, PbSe, PbTe, SnTe, $CuInSe_2$, $FeSi_{2.43}$, β-$FeSi_2$, $MnSi_{1.72}$, $CrSi_2$, $(Cr_{1-x}Mn_x)Si_2$, Mg_2Si, $BaSi_2$, $ReSi_{1.75}$, $RuSi_3$, $OsSi_2$ and Ir_3Si_5.

13. A magnetoresistive effect element according to claim 10, wherein said resistance adjustment layer contains as its major component one material selected from the group consisting of graphite, As, Sb, Bi, HgTe, HgSe, CoSi, $(Co_{1-x}Fe_x)Si$, $(Co_{1-x}Ni_x)Si$, $(Co_{1-x}Mn_x)Si$, $(Co_{1-x}Cr_x)Si$ and FeS.

14. A magnetoresistive effect element according to claim 10, wherein a thickness of said resistance adjustment layer is equal to or less than 3 nm.

15. A magnetoresistive effect element according to claim 10, further comprising an insulating layer located adjacent to said resistance adjustment layer and made of an oxide.

16. A magnetoresistive effect element according to claim 15, wherein said insulating layer is located nearer to a supply side of electrons forming said sense current with respect to said resistance adjustment layer.

17. A magnetic head comprising a magnetoresistive effect element having:

a magnetoresistive effect film including a magnetization-pinned layer having a magnetic film whose direction of magnetization is pinned substantially in one direction, a magnetization free layer having a magnetic film whose direction of magnetization varies in response to an external magnetic field, a nonmagnetic metallic intermediate layer interposed between said magnetization-pinned layer and said magnetization free layer, and a resistance adjustment layer interposed between said magnetization-pinned layer and said magnetization free layer and made of a material containing a quantity of conductive carriers not more than $10^{22}/cm^3$; and

a pair of electrodes electrically coupled to said magnetoresistive effect film to supply a sense current substantially vertically of the film plane of said magnetoresistive effect film.

18. A magnetic head comoprising a magnetoresistive effect element having:

a magnetoresistive effect film including a magnetization-pinned layer having a magnetic film whose direction of magnetization is pinned substantially in one direction, a magnetization free layer having a magnetic film whose direction of magnetization varies in response to an external magnetic field, and a nonmagnetic metallic intermediate layer interposed between said magnetization-pinned layer and said magnetization free layer;

a pair of electrodes electrically coupled to said magnetoresistive effect film to supply a sense current substantially vertically of the film plane of said magnetoresistive effect film,

wherein said nonmagnetic intermediate layer is a resistance adjustment layer made of a material containing conductive carriers not more than $10^{22}/cm^3$.

19. A magnetic reproducing apparatus which reads information magnetically recorded in a magnetic recording medium,

said magnetic reproducing apparatus comprising a magnetoresistive effect element having:

a magnetoresistive effect film including a magnetization-pinned layer having a magnetic film whose direction of magnetization is pinned substantially in one direction, a magnetization free layer having a magnetic film whose direction of magnetization varies in response to an external magnetic field, a nonmagnetic metallic intermediate layer interposed between said magnetization-pinned layer and said magnetization free layer, and a resistance adjustment layer interposed between said magnetization-pinned layer and said magnetization free layer and made of a material containing a quantity of conductive carriers not more than $10^{22}/cm^3$; and

a pair of electrodes electrically coupled to said magnetoresistive effect film to supply a sense current substantially vertically of the film plane of said magnetoresistive effect film.

20. A magnetic reproducing apparatus which reads information

magnetically recorded in a magnetic recording medium,

said magnetic reproducing apparatus comprising a magnetoresistive effect element having:

a magnetoresistive effect film including a magnetization-pinned layer having a magnetic film whose direction of magnetization is pinned substantially in one direction, a magnetization free layer having a magnetic film whose direction of magnetization varies in response to an external magnetic field, and a nonmagnetic metallic intermediate layer interposed between said magnetization-pinned layer and said magnetization free layer;

a pair of electrodes electrically coupled to said magnetoresistive effect film to supply a sense current substantially vertically of the film plane of said magnetoresistive effect film,

wherein said nonmagnetic intermediate layer is a resistance adjustment layer made of a material containing conductive carriers not more than $10^{22}/cm^3$.

ABSTRACT OF THE DISCLOSURE

A spin valve type magnetoresistive effect element for vertical electric conduction includes a magnetoresistive effect film in which a resistance adjustment layer made of a material containing conductive carriers not more than $10^{22}/cm^3$ is inserted. Thus the resistance value of a portion in change of spin-relied conduction is raised to an adequate value, thereby to increase the resistance variable amount.

FIG.1

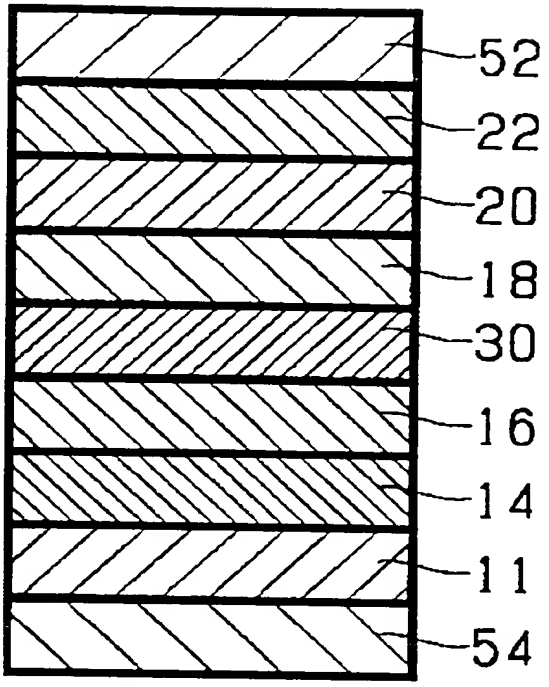


FIG.2

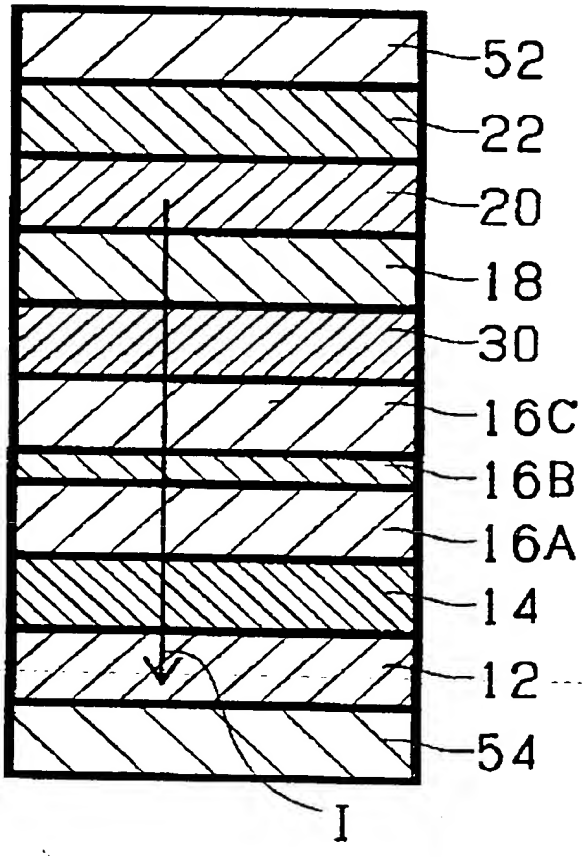


FIG.3

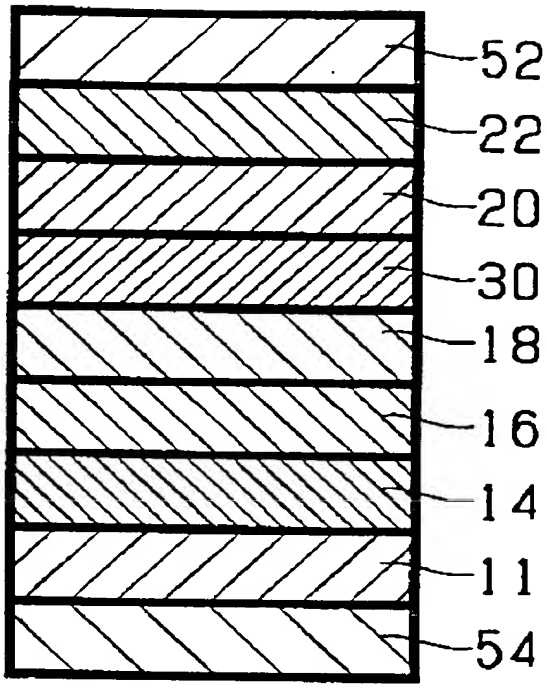


FIG.4

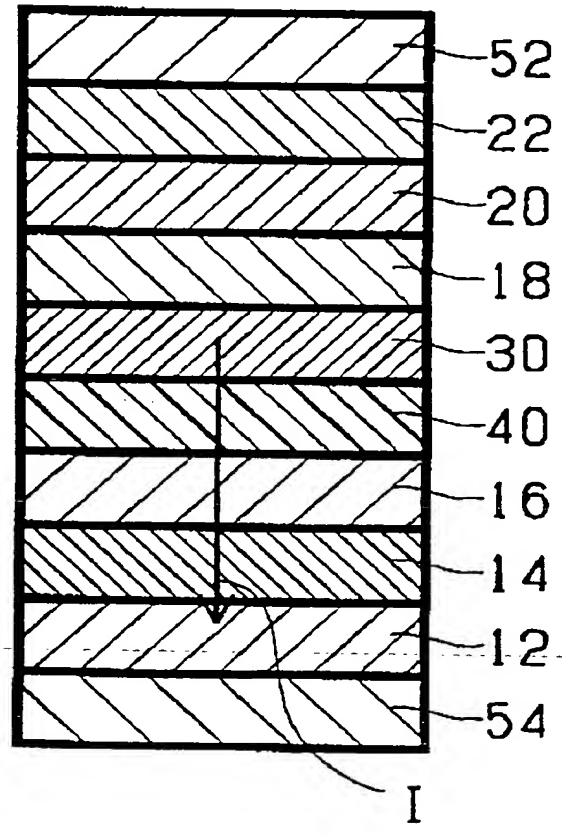


FIG.5

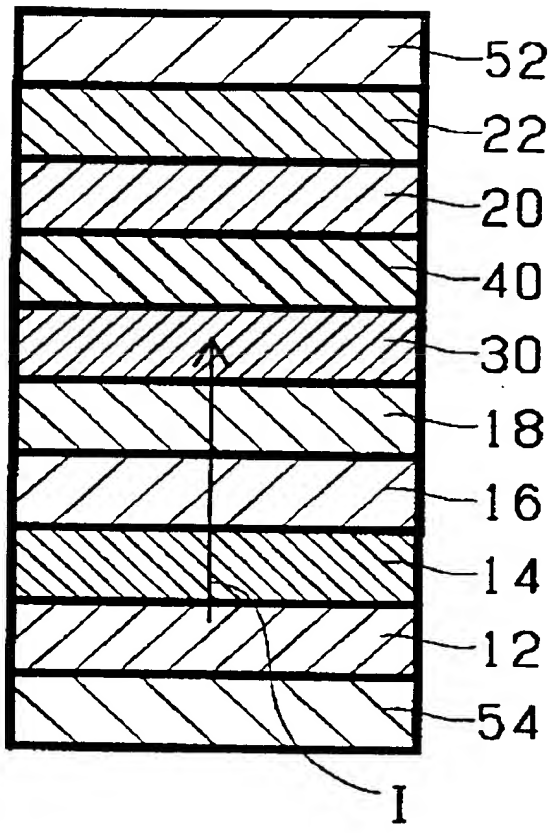


FIG.6

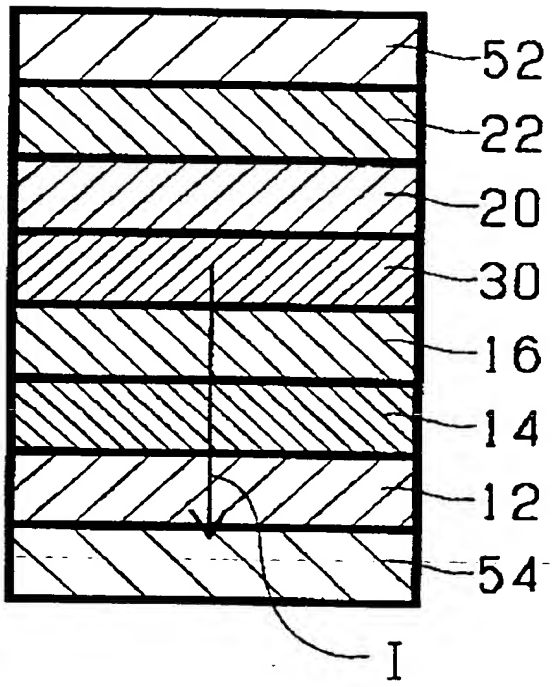


FIG.7

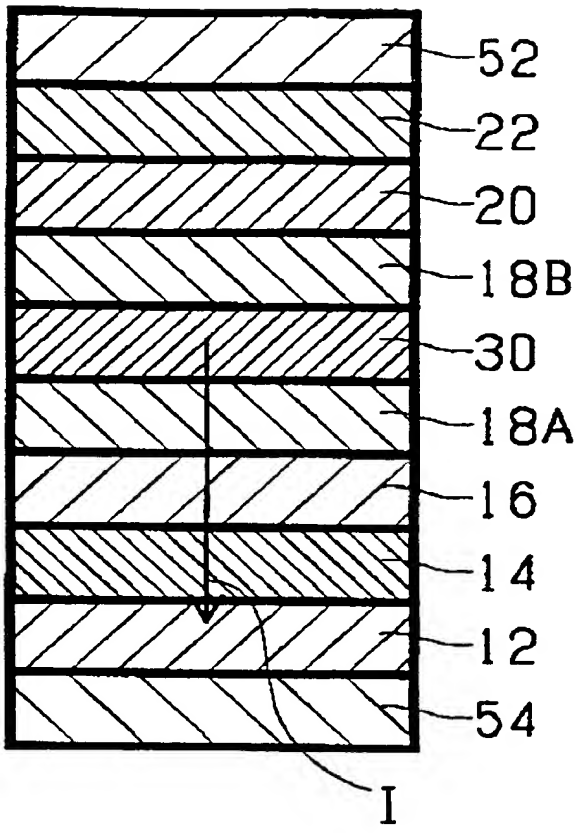


FIG.8

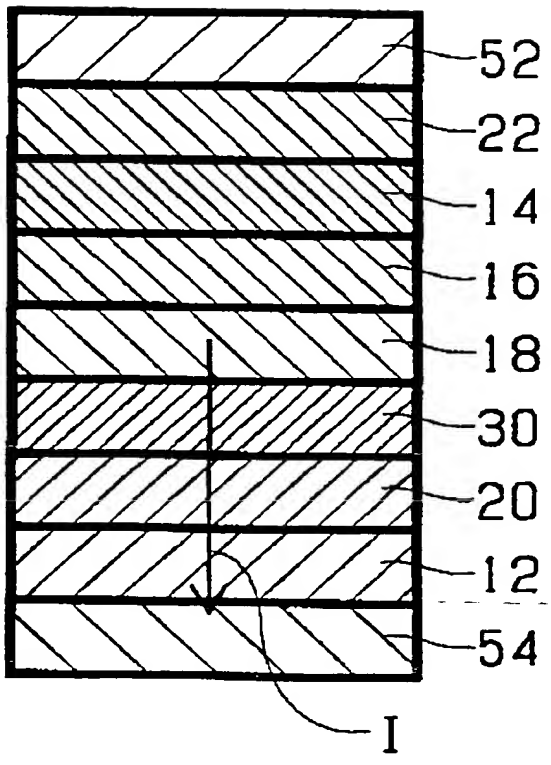


FIG.9

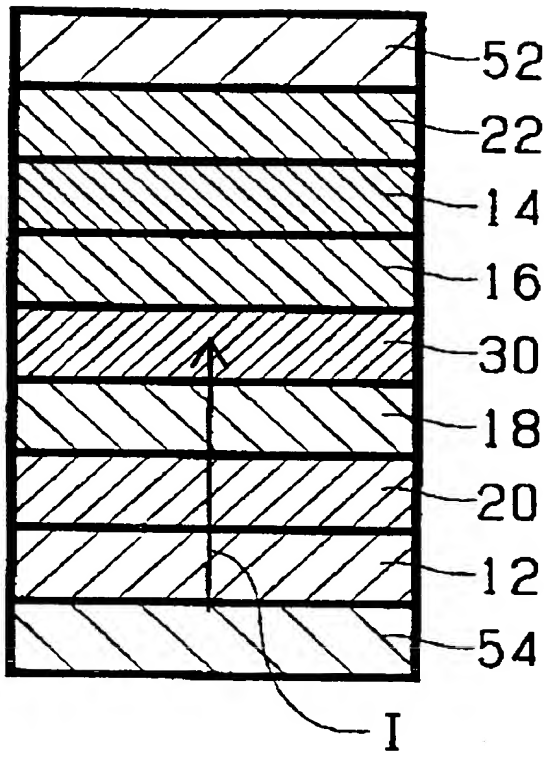


FIG.10

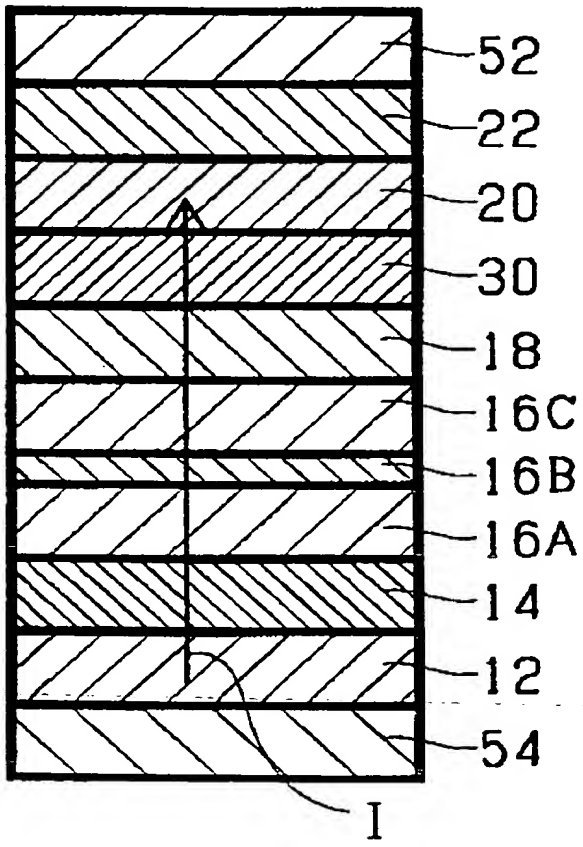


FIG.11

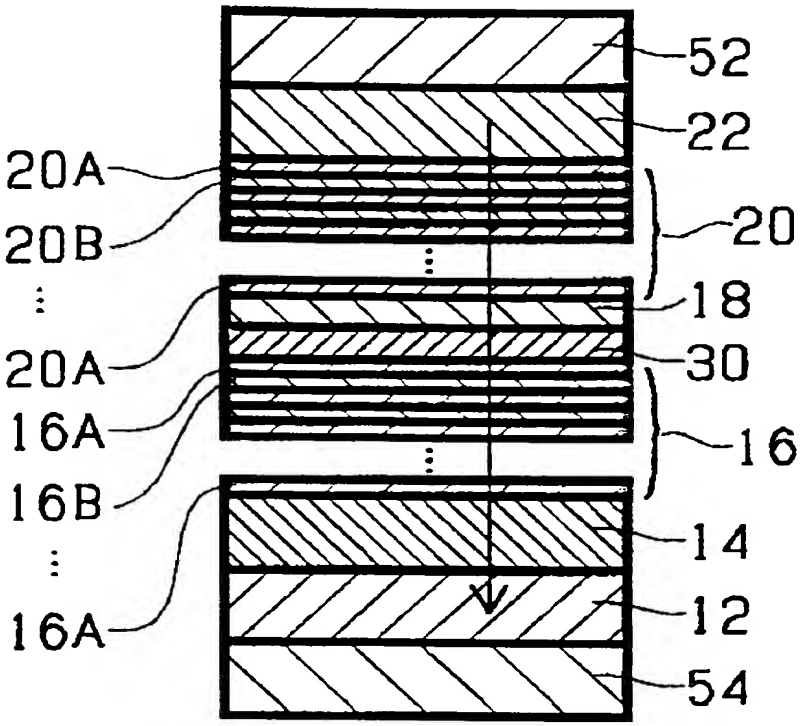


FIG.12

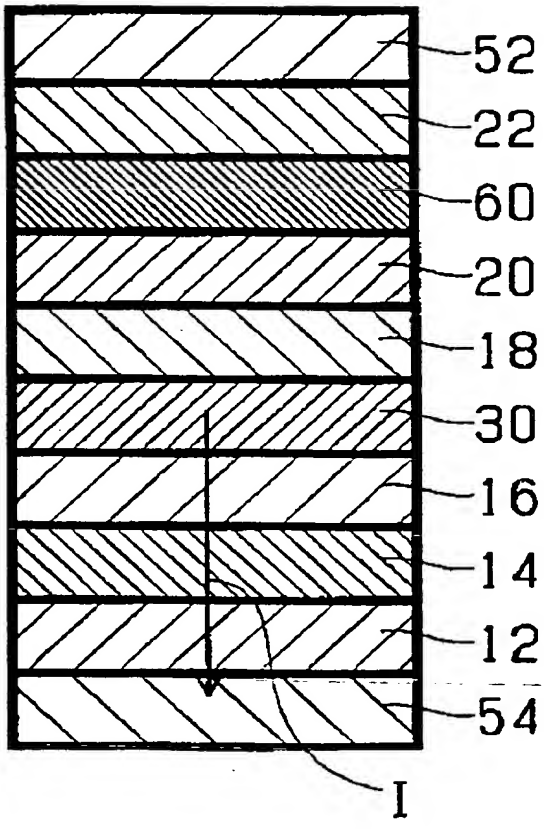
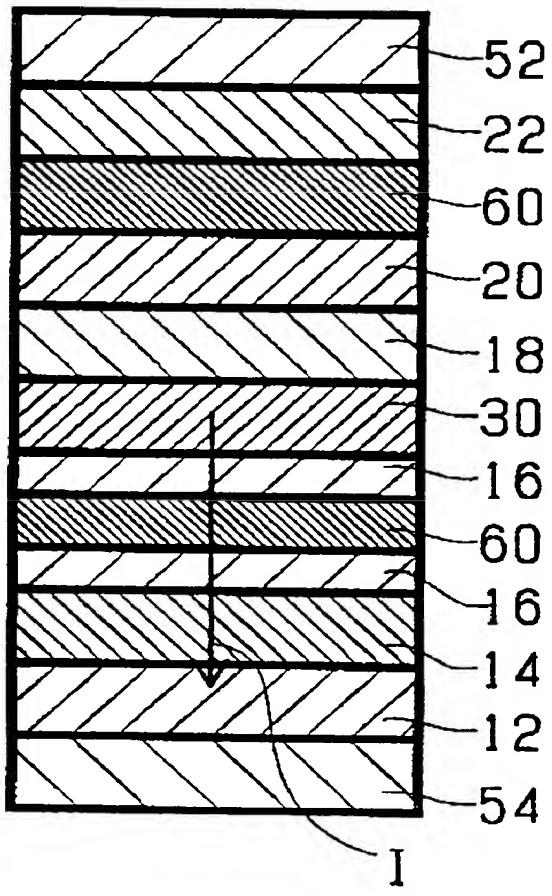


FIG.13



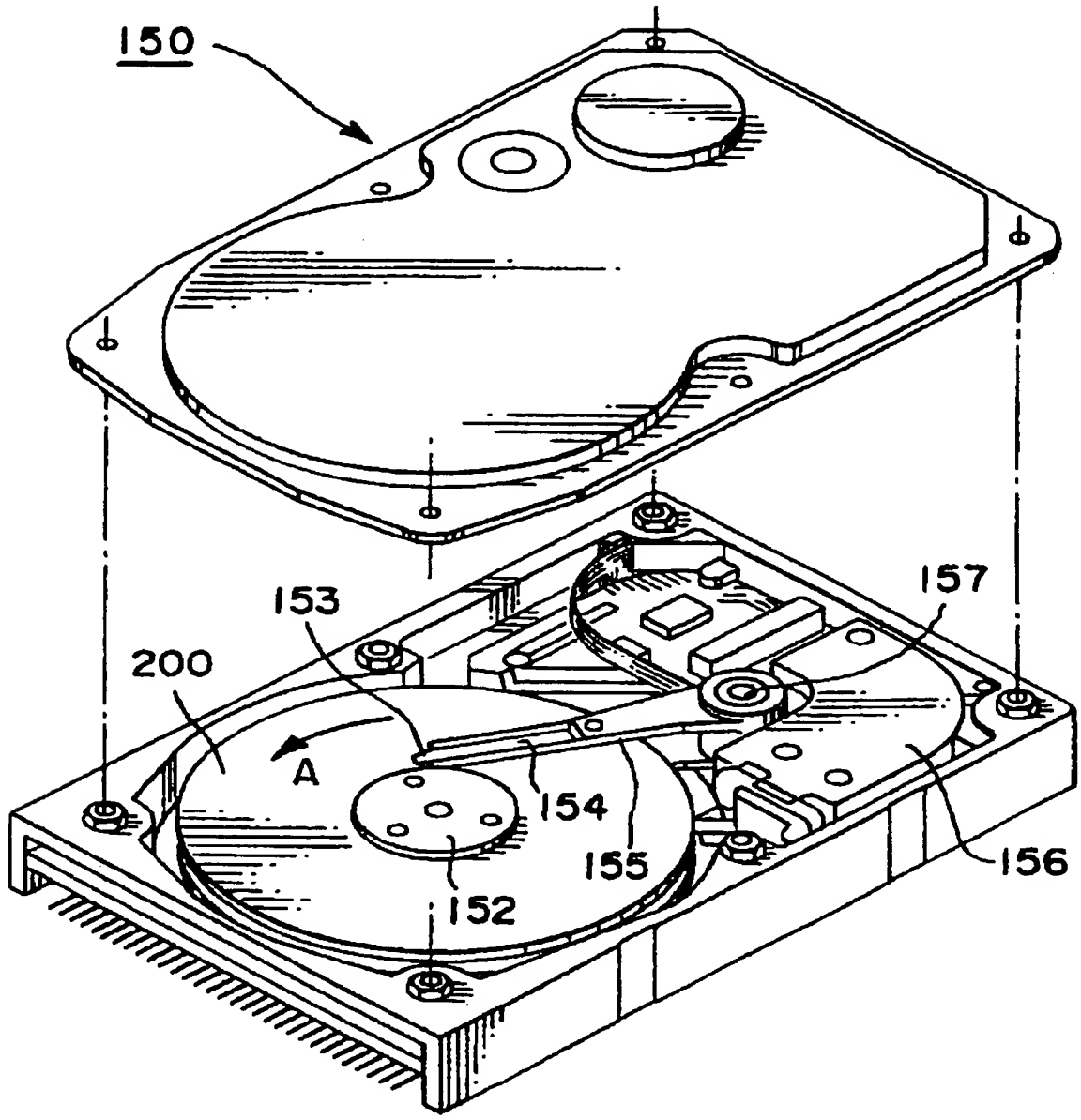


FIG.14

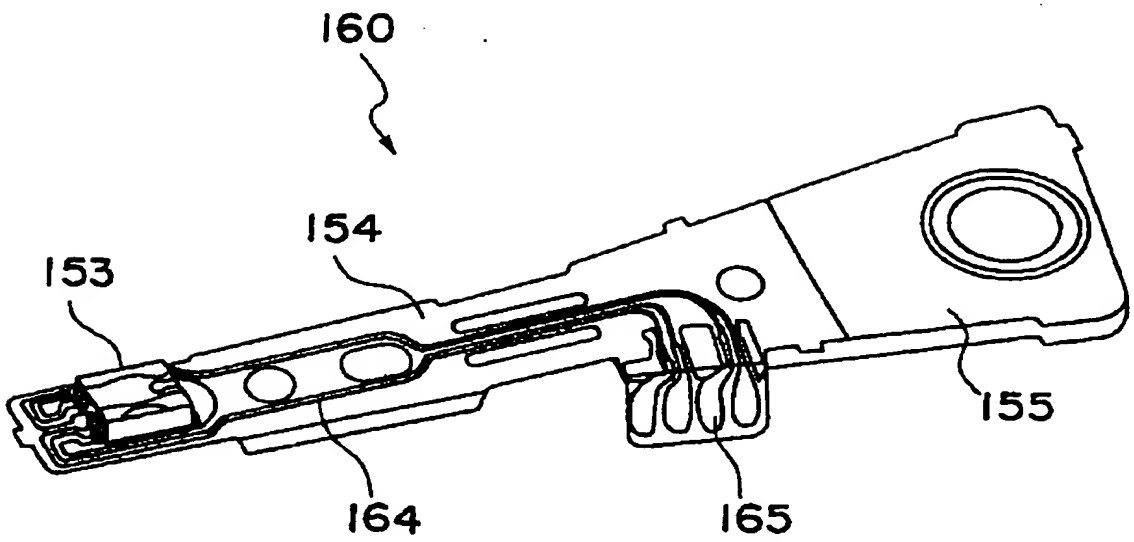


FIG.15

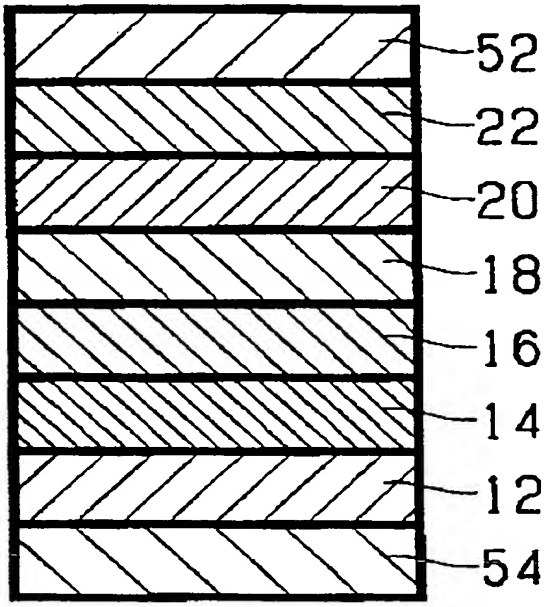


FIG.16